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U. S. GENERAL ACCOUNTING OFFICE

STAFF STUDY

PATROL FRIGATE

DEPARTMENT OF THE NAVY

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ABBREVIATIONS

PF Patrol Frigate
DSARC Defense Systems Acquisition Review Council
CNO Chief of Naval Operations
GAO General Accounting Office

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SUMMARY

PATROL FRIGATE

SYSTEM DESCRIPTION AND STATUS

The Patrol Frigate (PF) will be a new class of missile-equipped surface escort ships. Its primary mission will be to protect Navy amphibious and supply ships and mercantile convoys against enemy submarines and anti-shiping missiles.

As of January 1973, the PF was designed to be 440 feet long, to displace 3,500 tons, to have a sustained speed of 28 knots, and to have 4,500 nautical miles endurance at 20 knots. The ship will accommodate a crew of 185 personnel.

The ship will be driven by two gas turbine engines, aggregating 40,000 shaft horsepower. It will have one shaft and a controllable reversible pitch propeller.

The PF's weapons will include the STANDARD missile for air defense, the surface-to-surface HARPOON missile, the OTO Melara 76mm gun, and two torpedo tubes. The STANDARD missile and gun will be directed by a computerized MK-92 Mod 2 fire control system. The HARPOON fire control unit will work in conjunction with the MK-92 Mod 2 fire control system. Both missiles will utilize the same launcher.

The ship will be capable of supporting two IAMPS helicopters. The helicopter provides the ship with long-range anti-submarine warfare weapon delivery capability. It provides also the ship's long-range targeting information for the HARPOON missile.

The ship's target detection equipment includes radars (AN/SPS-49, MK-92 Mod 2 fire control system, and AN/SPS-55) and a direct path sonar (AN/SQS-505).

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As of January 1973, the PF program was in the ship system design phase. The contractors are the Bath Iron Works Corporation, Bath, Maine; and the Todd Shipyards, Seattle, Washington. Bath Iron Works has been designated as the lead shipyard. Todd Shipyards are to ensure that the ship design plans will be compatible with general shipbuilding practice, rather than optimized for one particular builder. Also, Todd Shipyards are to insure that adequate cost comparisons are available and a knowledgeable second lead shipbuilder is available if required.

COMING EVENTS

In June 1973, the Navy plans to award a cost-plus-incentive-fee contract for construction of the lead ship to the Bath Iron Works. In February 1975, the Defense Systems Acquisition Review Council (DSARC) is scheduled to decide whether to approve follow-on ship production. Data from integrated testing of the propulsion and weapon systems at land-based sites is supposed to be available for consideration by the DSARC in making this decision. If follow-on production is approved, the Navy plans to have the ships built by three contractors.

SYSTEM COST EXPERIENCE

As of June 30, 1972, the estimated cost of the PF program was \$3,134 million for the construction of 50 ships. This amount is an increase of \$402.5 million over the January 1972 planning estimate of \$2,731.5 million. The increase was due to (1) the inclusion of outfitting and post-delivery costs, (2) recomputing escalation and utilization of revised price indices, (3) changes in the ship's planned characteristics, and (4) a Navy decision to retain a ship set of combat system equipment permanently at the land-based test site.

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The estimate includes the cost of detection equipment and weapons except the IAMPS helicopter. The estimate does not include the cost of missiles, torpedoes, and ammunition.

The cost estimates were prepared by the PF project office. They include separate computations for the lead ship and for the follow-on ships. The estimates were based upon cost experience for other destroyer programs adjusted for differences in the complexity of the systems and inflationary effects. The Office of the Chief of Naval Operations (CNO) prepared an independent estimate which was only \$6 million more than the project office's June 1972 estimate. The Office of the CNO stated that the methodology of its estimate is accurate within plus or minus 10 percent.

Although the estimates were based on data available at the time, the General Accounting Office (GAO) believes that, as experience is gained in detailed ship design and lead ship construction, it may be necessary to revise the estimates. GAO has noted \$75 million in possible additional program costs. These costs are for weapons and equipment the ship may need but will not get during new construction. The Navy has made weight and space reservations on the ship for these items. The items are the Phalanx Close-in Weapon System, a digital data link system, and mechanical stabilizers.

Program funding

As of June 30, 1972, the PF program had received development funding totaling \$12.6 million--\$3.3 million in appropriated funds and \$9.3 million reprogrammed from other projects. Of this amount, \$9.7 million had been obligated and \$2.5 million expended.

Contract data

In April 1972, the Navy awarded two cost-plus-fixed-fee contracts totaling \$5 million for ship system design support. One contract was awarded to the Bath Iron Works and the other was awarded to Todd Shipyards

In October 1972, the Navy awarded a letter contract with a \$12 million ceiling for combat system integration services to the Sperry Rand Corporation, Long Island, New York.

SYSTEM PERFORMANCE EXPERIENCE

The PF's planned length is 420 feet, and planned displacement is 3,400 tons. As of June 30, 1972, only slight increases were noted in the ship's length and weight from the planning estimate. These resulted primarily from modifying the ship to accommodate a second IAMPS helicopter and refinements to the ship weight estimate.

SYSTEM SCHEDULE EXPERIENCE

As of September 1972, there had been no major schedule slippages on the program. Award of the first follow-on ship production contracts is planned for April 1975. Delivery of the lead ship to the Navy is planned for June 1977.

The IAMPS (MK-III) helicopter for the PF is not scheduled to be operational until after delivery of the lead ship. This helicopter will be a new airframe. A Navy official informed us that the lead ship is being designed to accommodate the existing IAMPS helicopter. However, the Navy stated that the new (MK-III) helicopter is being constrained to fit within the PF design envelope.

The other weapon systems are scheduled to be available prior to delivery of the PF to the fleet. The systems identified by the Navy as having high schedule risks are the MK-92 Mod 2 fire control system and the computer software integration system.

RELATIONSHIP TO OTHER SHIPS

The Navy plans to deploy the PF with existing destroyer escort ships such as the DE-1052 class, with the new DD-963 class destroyer, and with the proposed Sea Control Ship.

Compared with the DE-1052 escort, the PF will be comparable in length, 600 tons lighter, one knot faster in sustained speed, identical in endurance speed, and accommodate 75 fewer personnel. The DE-1052 has a single shaft 35,000 horsepower steam engine.

The PF and the DE-1052 are intended to operate with, and in support of, forces other than fast carrier strike forces. According to the Navy, the command and control capability and the anti-air warfare capability of the PF will be superior to the DE-1052 because the PF is designed with the fast reaction required to counter the anti-shipping missile threat to the protected force. The Navy stated that the DE-1052 class was designed in the early 1960s with a primary capability to counter the Soviet submarine and has only self-protection against anti-shipping missiles.

According to the Navy, the DD-963 will be a larger and faster ship with superior endurance, sea keeping, command and control, and anti-submarine warfare capabilities because it is designed to operate with and in support of our fast carrier task forces. It will also provide fire support for amphibious forces.

The proposed Sea Control Ship will carry helicopters and vertical/short takeoff and landing aircraft.

SELECTED ACQUISITION REPORTING

The PF program was not on the SAR system as of September 30, 1972. In view of the estimated program cost, GAO believes it should be on the SAR system.

MATTERS FOR CONSIDERATIONDesign-to-cost concept

DOD has adopted the policy of setting unit cost ceilings on new weapon systems. The ceiling is intended to result in the acquisition of simpler and lower costing weapons which meet essential needs only. This new approach is known as the "design-to-cost" concept.

The design to cost concept is being applied to the acquisition of the PF. The CNO has placed a ceiling of \$45 million in fiscal year 1973 dollars excluding shipbuilder escalation on the average cost of the 49 follow-on ships. The Navy indicated in its January 1972 planning estimate that if program costs were escalated to the planned procurement years, the average unit cost for follow-on ships would be \$51.5 million.

GAO noted that certain costs are not covered by the ceiling. They include (1) \$4.5 million for outfitting and post-delivery, (2) \$2.8 million for additional escalation, (3) \$.7 million for ship characteristics changes, and (4) \$.2 million for test and evaluation. These amounts represent the difference between the January 1972 and the June 1972 cost estimates. The inclusion of these costs would increase the estimated average follow-on ship cost to \$59.7 million.

In commenting on the design-to-cost concept, the Navy has stated that it will buy maximum performance if such performance can be obtained within the cost ceiling. The Navy has stated also that if the cost of obtaining maximum performance is too high, a lower costing product that meets essential requirements will be bought.

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With respect to the Navy's statement that it will buy maximum performance if it can be obtained within the cost ceiling, GAO believes that, as an alternative, the Navy should consider reducing the ceiling and buying only essential performance. This approach appears to be more consistent with the intent of the design-to-cost concept which is to acquire simpler and lower costing weapons that meet essential needs only.

The Congress may wish to discuss these matters with the Navy. GAO plans to review the design-to-cost concept in fiscal year 1974.

Fiscal Year 1974 funds

Funds for construction of the lead ship were made available in fiscal year 1973. In February 1975, the DSARC is to decide whether to approve follow-on ship production. It appears, therefore, that substantial fiscal year 1974 funds will not be required for the program.

Fiscal Year 1975 and later year funds

Before funds are committed for production of follow-on ships, the Congress should obtain information as to whether the integrated testing of the ship's propulsion and weapon systems at land-based sites has been successful. In considering any request for funds to install the Close-in Weapon System, the digital data link system, and mechanical stabilizers on the ship, the Congress should be informed as to whether these items are needed in order to meet essential performance requirements or whether these items will provide maximum performance.

AGENCY COMMENTS

A draft of the staff study was reviewed by Navy officials associated with the management of this program and comments were coordinated at the Headquarters level. The Navy's comments are incorporated as appropriate. As far as we know there are no residual differences in fact.

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CHAPTER 1

INTRODUCTION

The PF will be a new destroyer ship class the Navy intends to deploy in the late 1970s. It is to be a relatively low-cost escort ship for the purpose of maintaining unrestricted United States use of essential sea lanes. In addition, the Navy stated that it should fulfill the continuing need to replace retiring World War II destroyers.

The ship's mission is to supplement existing and planned escorts in protection of amphibious forces, underway replenish groups, and military and mercantile convoys. The ship will operate against enemy surface, subsurface, and air threats. Specifically, according to the Navy, it will provide increased capability to defend escorted forces against the anti-shiping missile and especially the submarine-launched missile.

As of January 1973, the PF was designed to be 440 feet long, to displace 3,500 tons, to have a sustained speed of 28 knots, and to have 4,500 nautical miles endurance at 20 knots. The ship will accommodate a crew of 185 personnel.

The ship will be driven by two gas turbine engines, aggregating 40,000 shaft horsepower. It will have one shaft and a controllable reversible pitch propeller.

The PF's weapons will include the STANDARD Missile for air defense, the surface-to-surface HARPOON missile, the OTO Melara 76mm gun, and two torpedo tubes. The STANDARD missile and gun will be directed by a computerized MK-92 Mod 2 fire control system. The HARPOON fire control unit will work in conjunction with the MK-92 Mod 2 fire control system.

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Both missiles will utilize the same launcher.

The ship will be capable of supporting two LAMPS helicopters. The helicopter provides the ship with long range anti-submarine warfare weapon delivery capability. It provides also the ship's long-range targeting information for the HARPOON missile.

The ship's target detection equipment includes radars (AN/SPS-49, MK-92 Mod 2 fire control system, and AN/SPS-55) and a direct path sonar (AN/SQS-505).

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This is the first report prepared by GAO on the status of the PF ship. It discusses the program's activities from its inception through June 30, 1972. Certain activities beyond June 30 are also discussed.

HISTORY

The Navy recognized a need to provide low-cost capable escort ships for protection of non-carrier naval forces and mercantile convoys as a result of two formidable developments in enemy capability. The new threats include an increasing anti-shipping missile capability and a continued increase in deployment of long-range attack submarines. In order to maintain control of the seas, the Navy has stated that non-carrier forces and mercantile convoys must be protected. This was identified in a high-level Navy study called Project Sixty.

Project Sixty, requested by the CNO, was conducted by the Project Sixty study group during July to September 1970. The study group stated that Soviet naval forces on the world's oceans have become a dominant power and that this threat necessitates greater U.S. naval presence. The study showed that increasing U.S. dependence on ocean-borne shipping of vital resources into this country makes the increasing Soviet threat even more immediate. It concluded that the Navy would have to take some new shipbuilding initiatives to provide adequate defense of essential sea lanes of transport which could be accomplished through construction of large numbers of small and inexpensive escorts.

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In September 1970 the CNO initiated a study to examine the design and feasibility of a new class of destroyer-type ship which would be optimized for a limited mission. The CNO stressed that a decision regarding the new ship's characteristics was needed within 18 months for use in preparing the Navy's future budget submissions.

In this study the CNO wanted to examine lower-cost alternatives to the DD-963 before reaching a decision regarding fiscal year 1975 destroyer funding. Study guidance provided by the CNO included (1) general mission, task, and concept of operations statements, (2) possible characteristics, (3) a range of features and options to be considered, and (4) a cost constraint of \$45 to \$50 million per ship. He also indicated that the equipment should be kept relatively simple, and the use of complex integrated hardware and software systems be avoided.

In January 1971 the CNO was apprised of the results of this study. Generally, it confirmed the feasibility of designing a ship in the \$40 to \$50 million range within the guidance provided. The study considered eight variations of new ship designs and recommended commencement of a comprehensive conceptual phase to further explore mission and design details. The study also established a plan for conceptual phase development which included preparation of specific operational requirements for the new ship. The CNO approved the recommendation to proceed into the conceptual phase and established the Patrol Frigate in project status. Project objectives were to:

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1. Define ship characteristics and performance requirements to minimize ship size and cost consistent with mission requirements.
2. Estimate total program costs with accuracy.
3. Produce the PFs at or below the program cost estimates. --

Concurrent with the CNO's approval of the PF project, the Deputy Secretary of Defense indicated the Navy should expedite action on a new design escort ship to be built in quantity for a unit cost of about \$50 million. The Secretary of Defense had been briefed by the CNO in September 1970 regarding Project Sixty findings and the need for new, inexpensive escort ships.

In May 1971 the CNO selected the ship type, weapons, sensors, and propulsion system. He determined that one common ship design would be used incorporating antisubmarine, anti-air, and surface warfare. In this regard, it was assumed at the beginning of the conceptual phase that different ship types would be required to most economically perform the desired mission. It was found, however, that any cost savings gained was more than offset by the added costs of specialization.

The CNO also established a follow-on ship cost threshold of \$45 million in fiscal year 1973 dollars exclusive of shipbuilder escalation and a size threshold of 3,400 tons. Before the cost and size constraints were established, studies were conducted to determine the new ship's unit size--and hence the unit cost--which would produce the

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maximum improvement to escort force effectiveness. The CNO specified that any changes in the ship's characteristics, even within established thresholds, would require his approval.

RESPONSIBILITIES

Primary responsibility for the management of the Patrol Frigate Project has been delegated to the PF Ship Acquisition Project Office, Naval Ship Systems Command. Under Naval Ship Systems Command Instruction 5430.101, dated August 1971, the project manager's major task is to be responsible for the development and procurement of the ship and to assure total ship systems integration for ship acquisitions assigned to him.

At the next higher organizational level, the Chief of Naval Material has established the Major Surface Combatant Ships Project Office. According to Naval Material Command Instruction 5430.49A, dated July 1972, the project manager is responsible for the planning, direction, control, and integration of all effort within the Chief of Naval Material organization relating to major surface combatant ships. The PF is one of the six ships classified as a major surface combatant ship. The other five ships are the landing helicopter assault (LHA) ship, the Spruance class destroyer (DD-963), the nuclear-powered aircraft carrier (CVAN), the major fleet escorts (DLGN, DG), and the Sea Control Ship.

Within the Office of the CNO, a program coordinator has been established in the Ship Acquisition and Improvement Division. The coordinator's primary

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responsibilities include serving as the principal advisor to the CNO on all aspects of the ship acquisition, serving as the CNO's single point of contact with the Naval Material Command on all aspects of the ship acquisition, and monitoring the progress of ship construction.

SCOPE

Information on this program was obtained by reviewing plans, reports, correspondence and other records, and by interviewing officials at the system project office, intermediate and higher commands of the Department of the Navy, and the Office of the Secretary of Defense. We evaluated management policies and the procedures and controls related to the decisionmaking process, but we did not make detailed analyses or audits of the basic data supporting project documents. We made no attempt to (1) assess the military threat or the technology, (2) develop technological approaches, or (3) involve ourselves in decisions while they were being made.

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CHAPTER 2

WEAPON SYSTEM STATUS

The Patrol Frigate ship program is currently in the ship system design phase of the acquisition process. In April 1972, the Navy awarded contracts for ship system design support to two shipbuilders-- Bath Iron Works Corporation, Bath, Maine; and Todd Shipyards Corporation, Seattle, Washington. The contracts were awarded to provide the Navy assistance during the ship design phase for ship design validation and producibility information. Accordingly, we have used information available at the ship system design contracts award date to establish the Navy's cost, schedule, and performance planning estimates for the program. The cost estimates in this information were developed by the Navy in January 1972 as part of the ship baseline validation.

A Defense Systems Acquisition Review Council meeting was held on this program in August 1972. As a result of this meeting, the Deputy Secretary of Defense authorized the Navy to proceed with development and construction of a lead ship, land-based test sites procurement, and advance procurement funding for long lead-time items. It was stressed that particular emphasis be placed on satisfactory weapon system testing prior to a full-scale production go-ahead. The Deputy Secretary of Defense also requested that periodic management reviews show the Navy's efforts in meeting an established follow-on ship cost goal of \$45 million in fiscal year 1973 unescalated dollars.

The CNO approved the Patrol Frigate Ship's characteristics in October 1972. According to the Project Manager, a formal ship acquisition plan has not been prepared but should be available by March 1973.

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Our review of the program's status as of June 30, 1972, showed that the Patrol Frigate ship has experienced increases in its cost estimates and other changes since its inception. Details of the program's cost, schedule, and performance are presented below.

SYSTEM COST EXPERIENCE

The Navy's estimated program acquisition cost for the Patrol Frigate ship program as of June 30, 1972, was \$3,134 million for the acquisition of 50 ships. This program cost reflects an increase of \$402.5 million over the January 1972 planning estimate of \$2,731.5 million.

Our review of the \$402.5 million increase showed that the amount was attributed to the following.

1. A \$221.1 million increase due to the inclusion of outfitting and post-delivery cost for 50 ships. This amount includes escalation of \$50.1 million. The planning estimate did not include these costs because estimates were not available.
2. A \$136.4 million increase to other escalation. This increase is the result of a recomputation of escalation for follow-on ship construction.
3. A \$34.3 million increase due to changes in the ship's characteristics and equipment. These changes are discussed in more detail on page 19 of this report.
4. A \$10.7 million increase due to recent emphasis on test and evaluation requirements. The Navy decided to retain a ship set of combat system equipment permanently at the land-based test site.

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The above costs identified for the Patrol Frigate do not include estimates for (1) IAMPS helicopters and supporting equipment, (2) missiles, torpedoes, and ammunition, and (3) personnel costs.

Possible additional program costs

In addition to the above, we noted other costs which could increase the cost of the program. These costs, which amount to at least \$75 million, are for equipment and/or systems which are planned to go on the ship after fleet introduction instead of during construction. In this respect, we found that the Navy is considering the installation of the Phalanx Close-in Weapon System, a digital data link system and mechanical stabilizers on each ship.

We were informed by Navy officials that these items were not included in program costs because no definite commitment has been made to put these items on the ship. While no commitment has been made, we found the Navy has provided weight and space reservations on the ship for these items. With respect to the digital data link system, we found the Navy is installing this system on other guided missile ships. We found, also, that mechanical ship stabilizers were installed on the DE-1052 destroyer escorts.

Economic escalation

The Navy has included about \$514 million for price escalation in the June 30, 1972, program costs. This is an increase of \$187 million over the escalation included in the planning estimate. According to a Navy official, the increase is attributed to (1) using fiscal year 1974 as a base instead of fiscal year 1973, (2) including escalation applicable to outfitting and post-delivery costs, and (3) adding escalation for increased costs due to changes in the ship's characteristics.

The \$514 million escalation amount is the total budgeted for the life of the program. In this regard escalation is included for (1) shipbuilder's contracts, (2) other shipbuilder's costs, (3) support and other program costs, and (4) outfitting and post-delivery costs. Contract escalation was computed using Bureau of Labor Statistics indices and learning curves for material and labor based on a basic construction target cost excluding profit. Escalation for other shipbuilder costs, support and other program costs, and outfitting and post delivery was computed using DOD-approved projection indices.

Appendix I shows a schedule of price escalation for the program.

Design-to-cost concept

DOD has adopted the policy of setting unit cost ceilings on new weapon systems. The ceiling is intended to result in the acquisition of simpler and lower costing weapons which meet essential needs only. This new approach is known as the "design-to-cost" concept.

The design-to-cost concept is being applied to the acquisition of the FF. The CNO has placed a ceiling of \$45 million in fiscal year 1973 dollars excluding shipbuilder escalation on the average cost of the 49 follow-on ships. The Navy indicated in its January 1972 planning estimate that if program costs were escalated to the planned procurement years, the average unit cost for follow-on ships would be \$51.5 million.

GAO noted that certain costs are not covered by the ceiling. They include (1) \$4.5 million for outfitting and post-delivery, (2) \$2.8 million for additional escalation, (3) \$.7 million for ship characteristics changes, and (4) \$.2 million for test and evaluation. These amounts represent the difference between the

January 1972 and June 1972 cost estimates. The inclusion of these costs increases the estimated average follow-on ship cost to \$59.7 million.

In the DD-963 and LHA programs, the Navy development process began by establishing specific mission and performance requirements and then designing the ship to meet these requirements. This approach, however, was modified for the PF in that ship performance was influenced, to a large extent, by the cost of systems being installed on it.

Our review showed that in its contracts for ship construction, the Navy is not planning to contractually define or establish total performance or mission capabilities. Navy officials informed us the Government will accept primary responsibility for the ship's design and, therefore, performance.

We found two examples where performance degradations could occur in the PF for a period of time as a result of equipment substitutions. In one instance, a change was made in the ship design to provide capability for two LAMPS helicopters instead of the one originally planned. As a result of the cost increases resulting from this design change, the AN/SQQ-23 sonar planned for the ship had to be given up for a less-costly direct path AN/SQS-505 type sonar. The AN/SQS-505 sonar also has considerably less capability than the AN/SQQ-23 sonar. Similarly, the electronic countermeasures equipment was changed from the more capable and more costly WLR-8 to WLR-1.

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Navy officials informed us that substituting equipment with less capability was offset by the added capability provided by the second IAMPS helicopter. We note, however, that the version of the IAMPS helicopter planned for the PF is not scheduled to be available until at least 3 years after the lead ship has been delivered to the fleet.

It appears, therefore, that performance tradeoffs have been made in order to maintain the cost goals. A Navy official informed us that tradeoffs can be made during the design phase, but these options decrease during the construction phase.

In commenting on a draft of this study, the Navy advised that in a design to cost program, neither performance nor cost is the main impetus and there is a balancing between the two. The Navy stated that "if maximum performance can be obtained within the cost target, the Navy will contract for and buy maximum performance." The Navy added that "if maximum performance entails costs so high that the Navy will be unable to purchase the numbers necessary to carry out its missions at sea, then a tradeoff may be made - but not to the extent that the cheaper product will not perform adequately."

With respect to the Navy's comment that it will buy maximum performance if it can be obtained within the cost target, we believe that, as an alternative, the Navy should consider buying only essential performance at a lesser cost. This approach appears to be more consistent with the intent of the design-to-cost concept which is to acquire simpler and lower costing weapons that meet essential needs only.

In summary, we believe that measures should be implemented to control the cost of weapon systems. It appears too early, however, to assess the effectiveness of the design-to-cost concept for accomplishing this purpose.

Before attempts are made to assess the effectiveness of this concept, further study is warranted. This study should consider matters such as the (1) costs appropriate for inclusion in the ceiling, (2) controls needed to assure the ceiling is not exceeded, (3) effect on operating and other costs not covered by the ceiling, and (4) impact on military effectiveness of sacrificing performance in order to meet the cost ceiling.

GAO plans to review the design-to-cost concept in fiscal year 1974.

Program funding

As of June 30, 1972, the PF program had received development funding totaling \$12.6 million--\$3.3 million in appropriated funds and \$9.3 million reprogrammed from other projects by the Navy. Of this amount, \$9.7 million had been obligated and \$2.5 million had been expended. Funds programmed through fiscal year 1973 are as follows.

	<u>Fiscal Year 1972 and prior years</u>	Millions \$	<u>Fiscal year 1973</u>
Development	\$12.6		\$ 1.5
Procurement	-0-		191.5
Construction	<u>-0-</u>		<u>-0-</u>
Total	<u>\$12.6</u>		<u>\$193.0</u>

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Contract data

As of June 30, 1972, two cost-plus fixed-fee contracts had been awarded for initial work on the PF. One contract, valued at \$3.2 million, was awarded to the Bath Iron Works Corporation, Bath, Maine; and a second contract, valued at \$1.8 million, was awarded to the Todd Shipyards Corporation, Seattle, Washington. Both contracts include ship system design support relating to the Navy's planning and design of the PF.

As of September 1972, changes to the Bath contract increased its value by \$.4 million to \$3.6 million, and changes to the Todd contract increased its value by \$.3 million to \$2.1 million. The changes primarily represent an extension of time to complete ship design support and the addition of selected design tasks.

On October 10, 1972, a letter contract for combat system integration was awarded to the Sperry Rand Corporation, Great Neck, Long Island, New York. The contract totaled \$8.8 million with an estimated ceiling price of \$11.8 million. The contract is expected to be definitized as a cost-type contract by February 1973.

Bath Iron Works has been designated as the lead shipyard. Todd Shipyards are to insure that the design plans will be compatible with general shipbuilding practices, rather than optimized for one particular builder. Also, Todd Shipyards are to insure that adequate cost comparisons are available and that a knowledgeable second lead shipbuilder is available if required.

In June 1973, the Navy plans to award a cost-plus-incentive-fee contract to Bath Iron Works for construction of the lead ship. If follow-on ship construction is approved, the Navy plans to have the ships built in three shipyards.

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SYSTEM PERFORMANCE EXPERIENCE

The PF's characteristics between the January 1972 planning estimate and the June 30, 1972, estimate showed only slight changes. These changes are shown below.

<u>Performance characteristic</u>	<u>Planning estimate</u>	<u>June 1972 estimate</u>
Size:		
Length	420 feet	440 feet
Weight (full load)	3,400 tons	3,500 tons
Weight (light ship)	2,280 tons	2,400 tons
Endurance	4,500 at 20 knots	4,500 at 20 knots
Speed	28 knots	28 knots
Crew	185	185

A project official stated the above changes in size were primarily the result of modifying the ship to include two IAMPs helicopters instead of one and refinements to the ship weight estimate.

SYSTEM SCHEDULE EXPERIENCE

The PF program schedule has not experienced any significant slippage as of June 30, 1972. Estimated delivery date for the lead ship is June 1977 and for the first follow-on ship, October 1978. Major program milestones as of June 30, 1972, compared to their planning estimate are shown below:

<u>Event</u>	<u>Planning estimate</u>	<u>June 1972 estimate</u>
Lead Ship contract award	April 1973	June 1973
Combat and propulsion system integration test	February 1975	February 1975
DSARC III ^a	February 1975	February 1975

^aTo decide whether to approve production of follow-on ships.

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<u>Event</u>	<u>Planning estimate</u>	<u>June 1972 estimate</u>
First follow-on ships contract award	February 1975	April 1975
Lead ship delivery	June 1977	June 1977
First follow ship delivery	August 1978	October 1978

The LAMPS (MK-III) helicopter desired for the ship is not scheduled to be operational until after delivery of the lead ship. This helicopter will be a new air frame. A Navy official stated, however, that the lead ship is being designed to accommodate the existing LAMPS. However, the Navy stated that the new (MK-III) helicopter is being constrained to fit within the PF design envelope.

The STANDARD missile is presently operational. The HARPOON missile is scheduled to be available for use on the lead ship. The OTO Melara 76mm gun is scheduled to be available in April 1976. The MK-92 Mod 2 fire control system is scheduled for delivery in September 1974.

Systems identified by the Navy as having schedule risks include the (1) MK-92 Mod 2 fire control system, (2) computer software integration, (3) OTO Melara 76mm gun, (4) propulsion system, and (5) diesel generators

The MK-92 Mod 2 is the heart of the ship's combat system. It is a foreign gun control system which is being converted to United States specifications. This involves the addition of a missile firing capability, change to a new computer, and adoption of a target illuminating system to work with anti-air warfare missiles.

The Navy considers the schedule risk associated with the MK-92 Mod 2 fire control system as high. The MK-92 program appears to be at least 6 months behind the original June 1974 schedule. A Navy official stated, however, that 3 months of this slippage has been absorbed through a schedule realignment and that promised deliveries do not jeopardize the PF program plan.

The computer software integration schedule risk is considered high and involves making the command and control programs and the MK-92 fire control system programs function together. The OTO Melara 76mm gun, the propulsion system, and the diesel generator are considered low schedule risk items. In our opinion, technical problems could be a cause of the schedule risks.

RELATIONSHIP TO OTHER SHIPS

The Navy plans to deploy the PF with existing destroyer escort ships such as the DE-1052 class, with the new DD-963 class destroyer, and with the proposed Sea Control Ship.

Compared with the DE-1052 escort, the PF will be comparable in length, 600 tons lighter, one knot faster in sustained speed, identical in endurance speed, and accommodate 75 fewer personnel. The DE-1052 has a single shaft 35,000 horsepower steam engine.

The PF and the DE-1052 are intended to operate with, and in support of, forces other than fast carrier strike forces. The command and control capability and the anti-air warfare capability of the PF will be superior to the DE-1052 because the PF is designed with the fast reaction required to counter the anti-shiping missile threat to the protected force. The DE-1052 class was designed in the early 1960s with a primary capability to counter the Soviet submarine and has only self-protection against anti-shiping missiles.

According to the Navy, the DD-963 will be a larger and faster ship with superior endurance, sea keeping, command and control, and anti-submarine warfare capabilities because it is designed to operate with and in support of our fast carrier task forces. It will also provide fire support for amphibious forces.

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The PFs and the DD-963s are partial replacements for World War II ships.

The proposed Sea Control Ship will carry helicopters and vertical/short takeoff and landing aircraft. Its mission will be to protect amphibious forces, underway replenishment groups, merchant convoys, and other naval units not protected by aircraft carriers.

The DE-1052 program is nearing completion. The DD-963 program is in early stages of production with first ship delivery scheduled for October 1974. The first Sea Control Ship is not scheduled for delivery to the fleet before May 1978.

SELECTED ACQUISITION REPORTING

The PF program was not included in the DOD Selected Acquisition Reporting System as of September 30, 1972. In view of the estimated program cost, GAO believes it should be on the SAR system.

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CHAPTER 3COST-ESTIMATING AND PROGRESS MEASUREMENT

Our review showed Navy internal program planning is still undergoing changes and that the only available contractor cost, schedule, or performance information was related to the preliminary design work on the ship. We did not examine this cost information because of the relatively small amount of funds involved (\$5.7 million). With respect to Navy internal planning, we found that ship cost estimates are becoming more definitized, and program management plans are being finalized. Details of these matters are discussed below.

SHIP COST-ESTIMATING

The Navy has prepared Patrol Frigate cost estimates for its fiscal year 1973 budget submission, its January 1972 baseline validation and its June 1972 Advanced Procurement Plan. We found there were no changes in the fiscal year 1973 budget and the January 1972 planning estimates. With respect to the June 1972 estimate, we found the program's cost increased by \$402.5 million. The methodology used in preparing these estimates and their validity and weaknesses are discussed below.

Fiscal year 1973 budget and
January 1972 estimates

In the President's fiscal year 1973 budget submission to the Congress, dated January 1972, the Navy indicated the Patrol Frigate ship program would cost \$2731.5 million. At the same time, the basic ship baselines were prepared and the cost estimate in this baseline did not change from the Navy's fiscal year 1973 budget submission. These

estimates were prepared by the Naval Ship Systems Command's Cost-Estimating Analysis Branch (estimator). The methodology used in computing these estimates considered the following ship cost categories: (1) plans and other design development, (2) basic ship construction, (3) Government-furnished equipment, (4) program factors, and (5) other costs. Cost estimates for the lead and follow-on ships were separately computed to reflect the basic Patrol Frigate procurement philosophy. This philosophy involves building a lead ship and including in the cost of this ship all the program's one-time, non-recurring costs. Follow-on ships would include costs for only basic ship construction, Government-furnished equipment, escalation, and program support. The assumptions and methods used to compute the lead and follow-on ship cost estimates are discussed below.

Lead ship costs

The costs for plans and design development include ship design, drawings development and preparation, mock-ups, noise reduction, ship and land-based test sites preparation, training, test and other plans preparation, and project management. Costs were essentially based upon cost experience of the DD-963 and DE-1052 class destroyer programs. Adjustments were made for assumed scope, complexity, and inflationary effects.

A major cost for the lead ship is its basic construction. These costs were calculated by the estimator from ship weight estimates provided by the Naval Ship Engineering Center (Engineering Center). The Engineering Center used as input ship characteristics for length, beam, displacement, speed, endurance, type and number of weapons, sensors, propulsion,

and other equipment. The total estimated weight was then computed for each of the following seven construction index weight groups: (1) hull, (2) propulsion, (3) electrical plant, (4) command and control, (5) auxiliary systems, (6) outfitting furnishings, and (7) weapons and supporting ordnance systems.

The estimator used the Engineering Center's estimated ship weight and determined labor man-hours and material costs per ton for each weight group based on weight-oriented cost-estimating relationships developed essentially from estimates of labor man-hour and material costs for the DD-963 destroyer program. The rates used to compute the production and engineering and labor costs were obtained from a composite of East, Gulf and West Coast shipyard charges for fiscal year 1973. In computing these costs, the estimator allowed a margin of 10 percent for weight growth. Additionally, costs for design and other services were priced as a percentage of the seven basic ship weight groups. Overhead was established at 72 percent of labor costs and was determined from East, Gulf, and West Coast shipyard charges. Profit was set at 12 percent to reflect sole-source procurement for lead ship.

Government-furnished equipment costs were obtained from price lists solicited by the estimator. Equipment costs for electronics, radars, propulsion systems, and generator costs were obtained from the Engineering Center; communication equipment costs from the Electronics Command; and fire control system, guns, and missile launching systems costs from the Ordnance Command.

Program factors relating to the lead ship include the dollar reserve allowances for various types of program growth items including change orders; electronics, hull/mechanical/electrical and ordnance growth;

future characteristics changes and contract escalation. Standard Navy allowances for all the above growth items except for future characteristic changes were included in the cost. As directed by the CNO, cost allowances for future characteristics changes were not established, and the CNO has directed that future changes to the ship be accomplished without increasing the ship's size or weight.

Lead ship other costs include subcontractor efforts administered by the project office and the Engineering Center. They include top level overview requirements, milestone scheduling, and program plans for various ship program areas. The costs of these efforts were estimated on a level-of-effort and requirements basis provided by the project office and were based upon costs from previous destroyer programs.

Follow-on ship costs

Costs for plan and other design development included ongoing lead shipyard design and service costs required to support follow-on ship construction through delivery of the last ship. Cost was developed on the basis that three shipbuilders would build the follow-on ships. Costs were computed based upon experience gained from other large shipbuilding programs and were divided equally among all follow-on ships.

The estimator computed basic construction costs for the follow-on ships using the lead ship values for man-hours per ton and material dollars per ton and by assuming cumulative average learning curves of 95 percent for labor and 98 percent for material costs.

The rates used to compute production and engineering labor costs were derived from a composite of charges for fiscal year 1973 from one shipbuilder each on the East, Gulf, and West Coast. In computing these

costs, the estimator allowed a margin of 8 percent for weight growth. Overhead was established at 90 percent of the labor costs and was determined from the composite above. The estimator assumed that three shipyards would receive competitively awarded, multiyear contracts in blocks mostly of eight ships each. Profit was established at 10 percent to reflect competitive procurement of the follow-on ships.

Government-furnished equipment costs were determined in the same manner as the lead ship. Program factors costs for electronics, hull/mechanical/electrical and ordnance growth and escalation were also determined in the same manner as the lead ship. However, costs for change orders were reduced approximately in half and future characteristics changes were not included. Only half of the normal allowance for change orders was used because the Navy plans that most changes will be made during the construction of the lead ship and that these changes will be included in the follow-on ship design. An allowance for future characteristic changes was deleted for the same reason given in the lead ship costs.

Follow-on ship other costs include Engineering Center support of the shipyards and were estimated on the assumption that three shipyards would build ships under multiyear contracts based on costs from previous destroyer programs.

Although both ship cost estimates appear to have been thoroughly computed based on extensive historical, current, and projected cost values/factors, the Navy considers the lead ship estimate to be a class D or engineering quality estimate but considers the follow-on ship estimate to be only a class 1, or ball park, estimate. A Navy official informed us the lead and follow-on ship estimates were computed from the

same data and that, technically, both estimates should be the same quality. However, the follow-on ships' estimate was not considered class D because it does not represent a complete engineering solution for the final ship baseline. A final ship baseline for the follow-on ships will not be available until October, 1974.

June 1972 estimate

In July 1972, the Chief of Naval Material approved an Advanced Procurement Plan for the Patrol Frigate which showed estimated program costs as of June 1972 to be \$3,134 million, an increase of \$402.5 million over the previous two estimates. The Navy prepared this estimate in the same manner as previously discussed. An explanation of the increase appears on page 16 of this report. Navy officials do not expect this estimate to change with the possible exception of escalation during the fiscal year 1974 budget preparation. They informed us that the estimates' quality will be improved during lead ship contract award and the fiscal year 1975 budget preparations.

Independent cost reviews

In the past, GAO has noted that independent reviews of weapon system cost estimates were not being conducted. We found the Navy has established procedures for conducting such reviews. In response to a December 1971 Office of the Secretary of Defense (OSD) Memorandum, entitled "Use of Parametric Cost Estimates," the Secretary of the Navy designated the Resource Analysis Group in the Office of the Chief of Naval Operations, as the cognizant Navy organization responsible for independent weapon system cost analyses.

The Resource Analysis Group's cost analysis of August 1972 showed that using the same program assumption, the ship project office's June 1972 estimate of \$2,899 million excluding outfitting and post-

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delivery costs was only \$6 million less than its estimate. A Resource Analysis Group official stated that the estimate was developed using a RAND Corporation ship costing model based on historical Navy shipbuilding data for destroyer programs back to World War II. He further stated that the Group computed the average follow-up ship cost and total program cost from this data and from the PF's characteristics.

According to this official, the only information provided by the project office was the ship's weight, propulsion system characteristics, crew size, and costs for the electronics and ordnance equipment. He stated that this cost data was used because this was the model's weakest cost-estimating area. The assumptions used in the model regarding the follow-on shipbuilding plan, the overhead and profit rates, labor and material learning curves, and change orders allowances (3.5 percent) were the same as the project office's. DOD indices were used to compute escalation.

According to the Resource Analysis Group's report, the Rand Model estimate less outfitting and post-delivery costs is accurate within plus or minus 10 percent.

Using the traditional allowance of 8 percent for change orders, the Resource Analysis Group prepared an estimate that was \$83 million more than the project office's estimate. According to the Navy, however, recently instituted configuration controls make the 3.5 percent change factor appear reasonable.

PROGRESS MEASUREMENT

Our review was limited to the techniques used to coordinate and monitor the Navy's current internal and contract ship design efforts and to the management actions which the project manager plans to use after award of production contracts.

Current efforts

We noted the principal management techniques used by the Navy for managing the ship system design phase of the program are (1) staff meetings and (2) periodic system status reports. We were informed by a project office official that staff meetings are the major communications device between project office and other Navy and contractor officials to obtain timely and factual information regarding the program's status.

This official stated that:

1. Internal project office meetings are held weekly for key staff and for the component managers. The staff meetings insure that all project office people are aware of current action items and other related information. The manager's meetings are between the project manager and his component managers. At these meetings basic project management, policy, planning, and guidance regarding future tasks are established.
2. Weekly meetings are held with the Engineering Center. At these meetings ship design schedules and other tasks, progress, and problems are discussed to insure that project office policy and plans are being properly implemented. The Engineering Center is responsible for preparing a ship design package for use in awarding production contracts.
3. Weekly meetings are held with the Commander, Major Surface Combatant Ships Project Office, Naval Material Command. Present at these meetings are the project managers of all six ship projects under cognizance of that office. During the meetings, problems common to the various ship acquisition projects as well as significant individual project problems are discussed.

4. The CNO's program coordinator meets frequently with project office officials to discuss program status as it affects the highest Navy levels. The primary purpose is to exchange information.

5. Weekly meetings are held with the shipbuilder's project managers.

The primary purpose is to exchange information.

Apart from staff meetings, the project office receives weekly, biweekly, or monthly status reports from the Engineering Center--the primary ship design agent--and the two design support contractors.

The Engineering Center currently submits biweekly management information reports which include information on space control drawings, combat system and communication diagrams, design budgets for weight, space and power requirements, master equipment lists, a manning summary, and a financial requirement summary for each major task. This information is amplified by submittal of a weekly status report on the basic ship design which the project manager uses to recommend action or provide redirection if required.

The Engineering Center and the participating shipbuilding contractors submit a monthly report during the design phase of the ship acquisition program. This report includes (1) total costs incurred for the month of the report and estimated funds required by contract line item to complete the work, (2) status of the work including identification of significant problems, any unresolved critical or major findings resulting from formal reviews, and any corrective action being taken, (3) identification of potential developments which may have cost, schedule, or technical impact, and (4) identification of work in progress and planned for the next month in detail sufficient to make a realistic assessment of status and progress.

as of September 1972 showed no significant schedule or cost variances. Minor variances reported were adequately explained and documented.

It should be noted, however, that because the design support contracts were not awarded until April 1972, availability of information was limited.

Future efforts

We were informed by a project office official that the Ship Acquisition Plan will be the primary program management document throughout the life of the program. The plan which will be updated annually to reflect program changes is expected to be completed by March 1973. This plan outlines the reporting requirements and other techniques that will be used by the project manager to control the activities of contractors and other commands within the Navy.

The Ship Acquisition Plan will be supplemented by more detailed plans for each of the three program management phases--design, lead ship, and follow-on ship production. These detailed plans will be used for day-to-day management guidance. Controls and techniques to be employed by the project manager are discussed below.

Ship design changes will be controlled by two groups that will function at different stages in the acquisition cycle. The Patrol Frigate Ship Design Review Board will review and evaluate alternatives and decide on design solutions recommended by the design teams during the early stages of the ship system design phase. The board will be responsible for determining whether the basic design represents a good technical solution for the ship the Navy wants. After ship design approval, this Board will cease to function.

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A second group, the Patrol Frigate Configuration Control Board, will approve or disapprove specific changes or additions to the latest documented design baseline including changes which will affect contract cost, delivery schedules, and data requirements. This Board will remain in operation for the life of the program.

Ship program costs will be monitored and controlled by the project manager in a number of ways. In one way, a cost control group will be established to maintain cost estimates for the total ship program that reflect the latest ship configuration and program plans. The group will, among other things, allocate dollar budgets and determine that each element of the program can be achieved within the budget. The cost control group will prepare program level and contract work breakdown structures forming the basis for the Government's independent cost estimate.

In another way, a quarterly Ship Cost Adjustment Review will be performed by the project office. This review will show program costs to date, estimated costs to complete, and the latest estimated cost at completion compared with budgeted costs, and will be formalized into a report and submitted semi-annually to the Navy Comptroller.

Project officials informed us that during the ship acquisition phase, the contractors will be required to implement DOD Instruction 7000.2, entitled "Performance Measurement for Selected Acquisition," issued in April 1972. The shipbuilders will have to furnish a ship construction work breakdown structure and also identify existing management control systems separately from proposed modifications to meet DOD Instruction 7000.2. We were informed by a project official the Navy plans to approve the lead shipbuilder's cost schedule control system prior to the contract award.

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During construction, the project manager will also require that the contractors submit monthly cost performance reports in compliance with DOD Instruction 7000.8, entitled "Cost Performance Report," dated April-1, 1970. The report will include information on technical, cost, and schedule performance related to the contractor's work breakdown structure items. It will also provide the early identification of problems having significant cost impact, effects of management actions taken to resolve existing problems, and program status information for use in making and validating management decisions.

In addition to reports submitted by the contractors, the project manager will receive monthly progress reports from the Navy's supervisor of shipbuilding at the shipyards. The reports will provide information required to monitor material allocation and ship construction schedules.

We were also informed that quarterly production progress conferences will be conducted at the builder's shipyards. The conferences will provide a thorough evaluation of the program and resolve problems affecting production schedules and timely completion of the ship. Participants will include representatives of the project office, shipbuilder, the cognizant supervisor of shipbuilding and, as appropriate, representatives of other material commands, and of Navy supply activities.

Because the program is only in its early planning stages, we could not evaluate the effectiveness of the above-stated procedures. It seems to us that as the program develops, these procedures will begin to emerge and then they can be properly evaluated.

ALLOWANCE FOR PRICE ESCALATION IN PROGRAM ACQUISITION

COST ESTIMATES

<u>Planning estimate</u>	<u>Development estimate</u>	<u>Cost changes</u>	<u>Current estimate (6/30/72)</u>
----- \$ millions -----			
\$327.1	(note a)	\$186.5	\$513.6 ^b
12 percent	(note a)		16 percent ^c

^aNo development estimate was available as of June 30, 1972.

^bDollar amount for price escalation included in current program acquisition cost estimates.

^cPercentage price escalation is of corresponding program acquisition cost estimate.

^dAccording to the Navy, the information presented herein is based on data developed as SCN budget submissions. In the case of the lead ship, cost type contracts will be used making it virtually impossible in the future to specifically identify the contribution of escalation as a separate element or cost. GAO believes that to assist in controlling program costs the Navy should attempt to identify escalation as a separate cost element. There may be a need to develop procedures for doing this where cost type contracts are involved.

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